Development of a Battlefield Management System: how to use the user

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Abstract

The Royal Netherlands Army (RNLA) is currently developing a demonstrator Battlefield Management System (BMS), which will support soldiers by displaying and distributing the available C2 information. Throughout the entire development of the BMS, the future military users play a very important role. There is frequent contact between users and developers and new versions of the BMS are presented to and evaluated by users every few months. The development consists of several cycles, while users are involved in nearly every step in each cycle. This leads to commitment of the user, because he notices that his comments are taken seriously and are usually implemented in the next version of the BMS. This user-centered approach has worked very well so far for both developers and military users. Several evaluations, in different settings and environments, have been conducted over the past two and a half years. This paper describes two of them in more detail, and also covers the user-centered approach that was taken in the development of the BMS. The paper explains the approach that was chosen by the RNLA, and discusses the advantages of this approach, as opposed to situations where users are not involved in the development of C2 systems.

1. Introduction

The Royal Netherlands Army (RNLA) is currently developing a demonstrator of a Battlefield Management System (BMS). The BMS will aid soldiers in performing their tasks by graphically displaying the available C2 information concerning own troops, enemy troops, terrain features and different plan overlays. In order to do so, a typical BMS will consist of several hardware and software parts. The main building blocks for a BMS are a computer and a screen, preferably a touch screen. Furthermore, a keyboard may be added in order to make it possible to enter textual information into the BMS. The BMS stations will be connected to a GPS receiver, in order to acquire information about the current location. In the future, other sensors, like a laser range finder, might be connected. For the distribution of the information, the BMS uses combat net radio communication. However, in more static environments, a Local Area Network (LAN), or a wireless LAN might be used.

A team consisting of representatives from the RNLA, several software companies and TNO Defense Research has been formed in January 1999 and will be continuing the

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development of the BMS until at least the beginning of 2002. Around mid 2001, 30 systems will be handed over to the RNLA. In 2002, a battalion-sized unit will be equipped with the BMS. This battalion will use the BMS during their peacekeeping operation in Bosnia. The project schedule is depicted in Figure 1.

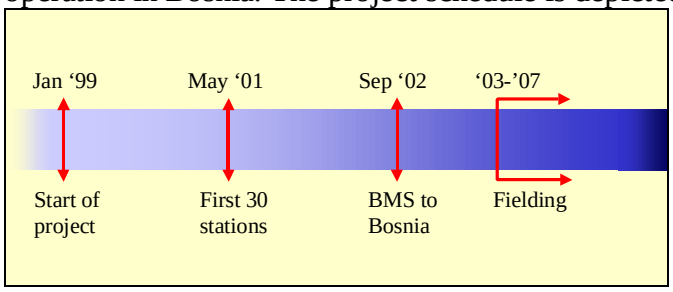

Figure 1: Time schedule

The main goal of developing the demonstrator is not to deliver a fully operational system, but to define and evaluate the functional and technical requirements that should be imposed upon an operational BMS. Another important goal is to gain insight into the operational benefits of using a BMS. The final operational BMS will probably be developed by industry. The results of the demonstrator phase (functional and technical requirements) will form an important input to the procurement phase.

Although there are many issues related to the development of a BMS, this paper will focus on the iterative approach that has been adopted and in particular on the active user participation. To put all things in perspective, the next chapter will first describe the environment in which BMS will operate and the challenges that need to be addressed. After that, chapter 3 will be entirely devoted to the current and future users of the BMS and in chapter 4 some conclusions are presented.

2. The world around the BMS

2.1 Environment

The Dutch BMS will be used at the levels of battalion and below, down to the single vehicle. At each echelon, the BMS will be fitted into different types of vehicles, such as tanks and armored personnel carriers. This means that special attention needs to be paid to the harsh environment in which the BMS will operate.

Inside the vehicles, it can be cold, wet, noisy, dirty and shaky. Furthermore, users might wear gloves when operating the BMS. This imposes special constraints upon the design of both hardware and software. For example, the current version of the BMS has a touch screen and very large buttons, in order to make it possible to operate the system while wearing gloves. Special requirements apply also to reliability and user-acceptability of the BMS.

The RNLA has also some other C3I systems at her disposal, which have to interact with the BMS. The BMS will have to exchange information with the Dutch Integrated Staff Information System (ISIS) for brigade and division-level and with the Soldier Digital

Assistant (SDA), which is a C3I system on a handheld computer, being developed for the individual soldier. This is shown in Figure 2.

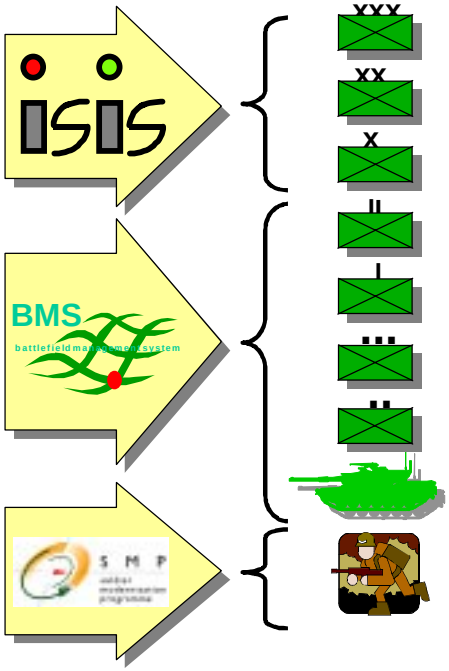

Figure 2: C3I systems in the RNLA

In the near future, a migration of the C3I systems towards a so-called C2 workstation will be performed. This will be a generic system, based on the RNLA-C3I-architecture. The C2 workstation can have different appearances at different echelons, in order to meet the operational and ergonomic requirements. The C2 workstation enables a more integrated and streamlined approach to C2 on all echelons, from soldier to army corps. Re-use of software components and a more uniform way of distributing data are two other advantages of this approach.

2.2 Challenges

When developing a BMS, one encounters many challenges. This section describes some of them.

1. **Hardware.** The hardware that is used for a BMS needs to withstand a great deal. Since the BMS will be built inside vehicles, special environmental conditions might occur. Inside vehicles, it can be wet, cold, hot, very light or quite dark, and there might be a lot of dust and dirt. Furthermore, since soldiers typically move around inside their vehicles, they might bump into the hardware with their boots or other parts of their gear.
2. **Fitting hardware into vehicles.** Most vehicles are already stuffed with equipment, and the personal gear of the soldiers is added to that. In most vehicles it is therefore difficult to find a space for the BMS. Added to that is the fact that the BMS needs to be in a place where the user can operate it in a safe and healthy manner. It is clear that a screen that is positioned right behind the head of the user is not very easy readable. Also the incidence of light inside the vehicle can be a limiting factor when

determining the best location for the BMS. In Figure 3, the inside of a tracked vehicle is shown, while a soldier operates a touch screen.

Figure 3: Trying to find the best location for BMS inside a vehicle

3. **Data communication.** All exchange of information within the BMS network and between BMS and other C3I systems is handled through a digital military radio, which has a very limited bandwidth. This means that much consideration is given to the question which data needs to be distributed at which intervals. Typically, (military) users want as much information as possible, but because of the limited bandwidth, they have to make a trade-off between diversity and timeliness of information. However, when the staff of a battalion is deployed in the field, there sometimes is the possibility to use a (Wireless) LAN. This means that the available bandwidth is increased, and therefore more information might be distributed within the staff. Besides the limited bandwidth, combat net radio communication is not always reliable, and the network might not always be fully connected.
4. **Training.** The future users of the BMS need to be trained in using the system. During the past evaluation cycles, the training consisted of one day of instruction in a classroom. In the future, military instructors need to be trained, so they can train the rest of the military personnel. Training involves more than just knowing which buttons to push. Users also need to learn how to gain an operational advantage from using the BMS.
5. **Interoperability.** As stated before, the BMS is not the only C3I system in the RNLA. Therefore, attention needs to be paid to the integration between the different systems at the different echelons. Besides that, military operations these days are very often international, which means that also interoperability between C3I systems from different countries is important. Attention needs to be paid both to the technical solution and to the question which information needs to be distributed.
6. **Functionality.** Since there was no clear description of what functionality a BMS should contain, already at the beginning of the project there were many meetings with the military. Since there was also no clear indication of the exact user needs, the decision was made to develop a demonstrator. An initial set of requirements was drawn up before the start of the initial design and implementation. During the last two years, additional requirements have come up and existing requirements were dismissed. In addition to the required functionality, military users have to decide what kind of information they need.
7. **Man machine interface.** Because of the special environment in which a BMS is used, special attention needs to be paid to the man machine interface (MMI). Many

interface controls are hard to operate when working with a touch screen, especially while you are inside a moving vehicle. This was the reason that many controls could not be used in the MMI of the BMS. A good example of a control that is hard to use is the well-known scrollbar. Scrollbars are typically too small to be accurately positioned, and the entire concept of 'drag and drop' is particularly difficult when using a touch screen. However, early evaluations and foreign experiences have shown that using a touch screen is still a very good option. C3I systems that operate on higher echelons do not have these problems, because these systems will be used in an environment that is very similar to a regular office.

8. **Evaluations.** At different stages during the development of the BMS, evaluations are carried out. With each evaluation, future users are confronted with a not-yet-completely-finished system. It is very important to emphasize the importance of their contribution to these users. Because of their comments, the next version of the system will be better suited to the military tasks and better suited to the environment in which it needs to operate.

Although the first five challenges mentioned above are very interesting in themselves, this paper will focus on the challenges six through eight. The thing these three challenges have in common is that the user is always at the center of interest. Throughout this paper, the emphasis is on the operational user, that is, the user who uses the BMS while participating in a military operation. It is well known that there are also other user groups, such as users who perform maintenance or configuration of the BMS, but these user groups fall beyond the scope of this paper.

3. Using users

3.1 Introduction

As stated before, the future users of the BMS play a very important role in the development of the system. The RNLA has earmarked the 13th mechanized brigade as 'the digital brigade'. This brigade is involved in evaluations and will be the first brigade to actually utilize the operational BMS.

The brigade has appointed a digitization liaison officer whose task it is to coordinate the projects that are related to digitization. This officer is now also a member of the BMS team. Amongst other things, he is responsible for the communication between the BMS team and the operational users. He also has an important task when it comes to public relations, because most users are more impressed when an army officer tells them about BMS than when a civilian scientist tells the same story.

So far, users have been very enthusiastic and cooperative. This is very important for the evaluations, because enthusiastic users will give the most valuable comments, both positive and negative. Most users try to think along with the developers and come up with good solutions for the problems encountered. The users also supply suggestions for new functionality. Finally, users have been very 'forgiving' towards the BMS. Apparently, they recognize the potential benefits of such a system and they trust that problems that surface during evaluations will be solved in due course.

3.2 Approach

In order to elicit the requirements for BMS, an iterative approach is adopted. The reason for this was that at the start of the project, there was no clear understanding of the required functionality. There had been some interactions with users, some foreign developments were known and some people had a gut feeling about what a BMS should do. One of the activities that have taken place at an early stage was the evaluation of two foreign BMS'es. Together with a few future users, scenario's were drawn up and 'played' afterwards, while using the system under evaluation. The result of this evaluation was a long list of possible requirements for a Dutch BMS. In contrast to the foreign systems, which were especially developed for reconnaissance and tanks respectively, the Dutch army wants to aim for a generic BMS, with functionality that is useful for all types of units. At a later stage, more specific functionality could be added.

From the official start of the project, in January 1999, an iterative approach with relatively short cycles was adopted. This made it possible to develop the BMS in a flexible way and by evaluating small components of the system at a time, the users could be consulted frequently. Figure 4 depicts a cycle in the development process of the BMS.

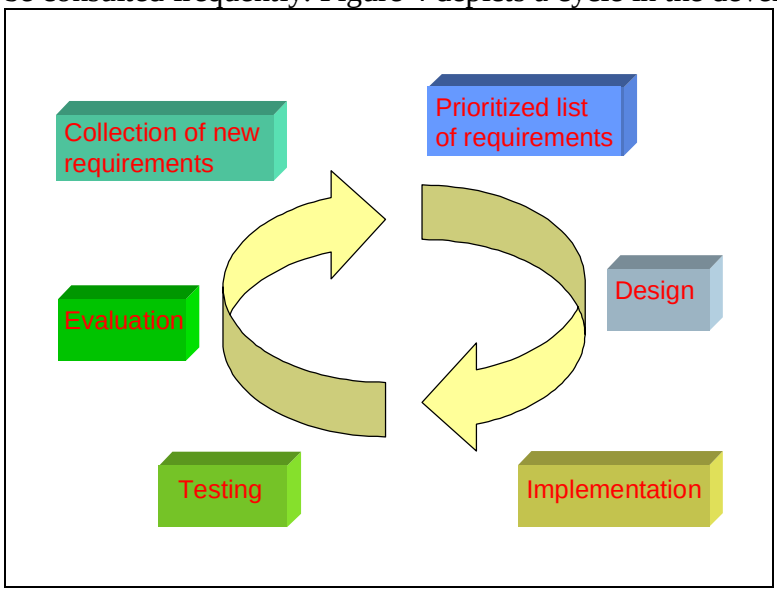

Figure 4: development cycle

Each cycle in the adopted approach usually takes about four to five months and consists of the following steps:

1. **Prioritization of requirements.** The military representatives in the project team are actively involved in the prioritization of requirements. For each requirement, the development team determines the estimated time needed to implement the functionality. After that, the user is asked to participate in the final prioritization. The motivation for assigning a high priority to a specific functionality might be dependent on the type of evaluation that will be performed at the end of the current cycle.
2. **Design.** The prioritized list leads to an implementation schedule. This schedule contains an estimate of the time needed to design and implement the new functionality. When it is clear what functionality is to be added to the BMS in the current cycle (dependent on the available time), the design phase starts. During this

phase, military users frequently meet with designers and developers in order to explain and discuss the visual and technical aspects of the new functionality. Also the user interaction is defined. The result of this phase is a set of documents, that is, the functional and technical designs. More information about the design of the user interface can be found in section 3.3.

3. **Implementation.** During the implementation period, the military representatives meet with the project team every week and look at intermediate versions of the BMS and give their first comments. Because of the frequent contact between military users and software developers, the latter gain a better insight in the purpose of the system they are developing and this helps them to actively participate in inventing solutions when problems occur.
4. **Testing.** Some time before the next evaluation, usually four or five weeks, the implementation is stopped. This moment is more or less independent from the results that have been achieved so far. This is because the evaluation period has been agreed with the users from the 13th mechanized brigade and cannot be rescheduled. The next few weeks are used for testing the new functionality, the integration of the new functionality with the old system and the fixing of bugs that surface.
5. **Evaluation.** When a new version is finished and tested, the BMS is evaluated during an evaluation period. More detailed information about the evaluation is given in section 3.4.
6. **Collection of new requirements.** After that, all comments made during the evaluation are listed and the next cycle starts with a new prioritization.

3.3 Use cases

A major part of the development effort is devoted to designing and implementing the man machine interface (MMI). All interactions with the BMS need to be simple and quickly. Users must be able to operate the system in every environment they might find themselves in. Also the system must be easy to learn.

In designing the MMI, so-called use cases are frequently used. Use cases have their origin in the object-oriented design world and have proven to be a very good means of communication between users and developers. This is another way in which the users of the 13th mechanized brigade are involved in the BMS project. Use cases can be seen as small scenarios that describe the interaction between the user and the system. The use cases are stated in human language and are reviewed by both military users and developers. Very often, sketches of screen layouts are provided with the use cases to give the users an idea of what the BMS will look like. Every use case represents a task that is recognizable by the user. For example, one such use case is ‘enemy spot report’. This use case describes the actions the user has to perform to create an enemy spot report and also the appearance and actions of the BMS.

3.4 Evaluations

Every four to five months, the user is asked to participate in an evaluation of the BMS functionality that has been developed. Usually, each evaluation focuses on a specific part of the BMS. For example, there have been evaluations of the data communication, (parts of) the MMI and the functionality for creating and distributing plans.

The scale of the evaluations ranges from two single users to the entire staff of a battalion and evaluations were held both in an office environment and in the field.

Before an evaluation, the users familiarize with the BMS during a one-day training course. This training course takes place in a classroom, where about 20 students are trained on 10 BMS workstations. Usually, common desktop computers are used. The outline of the training is as follows:

1. Introduction and walk-through of the BMS interface.
2. Exercises for the students to perform. This gives them hands-on experience with the interface and symbols that are used in the BMS.
3. Explanation of procedures concerned with creation and distribution of plans.
4. Exercises for the students, focused on the planning process. The students follow the entire process of creating a plan, sending it to their subordinate commanders and receiving their contributions to the plan.
5. Time reserved for questions and remarks.

The evaluation itself usually starts with the BMS team crawling through armored vehicles to fit the BMS station and other hardware parts into the vehicles. After that, the exercise starts and the BMS team changes from an executing to a monitoring role. When a problem occurs, a specific member of the team is assigned to solve it, dependent on the nature of the problem (data communication, software, and functionality). Since exercises typically are run on a 24-hours basis, the BMS team is also available during the nights.

During the entire evaluation, observers are present who observe the users while they work with the BMS. These observers come from the TNO Human Factors Institute and have a thorough understanding of both the BMS system and the tasks that need to be performed by the military users. The observers report their observations by means of observation checklists. At several specific moments during the exercise they also hand out questionnaires for the users to fill out. These questionnaires are very short and easy to fill out. It typically takes the user less than five minutes to complete them. At the end of the exercise, users are asked (or ordered by their commander) to fill out a more elaborate questionnaire. In this questionnaire, very detailed questions about the functionality, visual and interaction aspects need to be answered.

After an evaluation, a report is written which lists the observations that were made by the observers and the users. Usually, the number of proposed alterations to the system, deduced from the recorded observations, exceeds the time available before the next evaluation, so a prioritized list of comments is compiled. This way, the user will experience in the next evaluation that many of his observations are addressed. This helps in keeping the user motivated to take part in the evaluations.

The next two sections describe evaluations that were performed in June and October 2000.

3.4.1 Evaluation 'Digital Rat'

The evaluation 'Digital Rat' was conducted in June 2000. The objective of the evaluation was to determine whether the functionality that was implemented in the BMS, together with the data communication through the military radio, was sufficient to cover the need for Situational Awareness of a reconnaissance platoon. Besides that, the configuration of the BMS stations was such that the captain in charge with exercise control could monitor the positions of both the reconnaissance platoon and the two vehicles that acted as enemy. This enabled the exercise controller to coordinate and evaluate the exercise.
The situation during the evaluation is depicted in Figure 5.

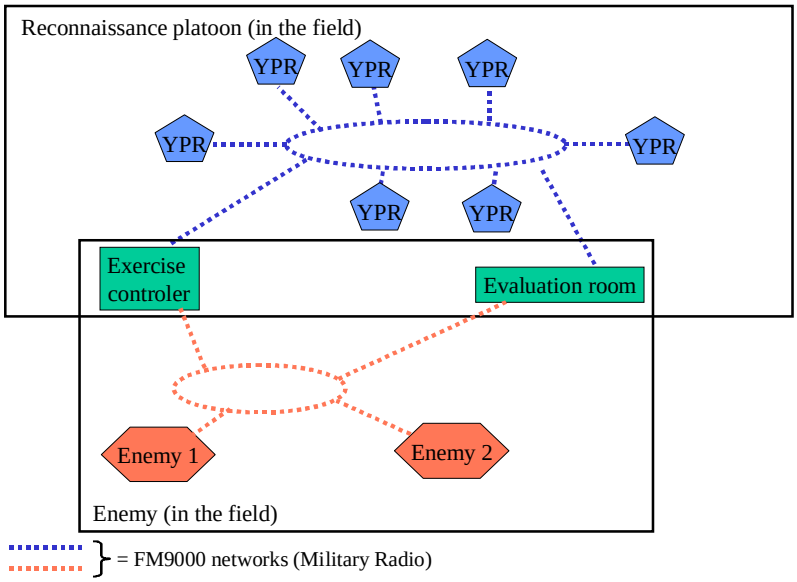

Figure 5: Digital Rat configuration

A reconnaissance platoon consists of seven tracked vehicles, in this case YPR's. The BMS stations were mounted on top of the vehicles, next to the commanders' hatch. The YPR with the computer on top of it is shown in Figure 6.

Figure 6: YPR with BMS station

During the week of the evaluation, the reconnaissance platoon had to perform several different tasks. Amongst them were observing an enemy, guard an area and reconnaissance of objects and routes.
At the end of the evaluation, the user came to the following conclusions (only conclusions that fall within the scope of this paper are listed):

- Nearly all participants were very positive about the development of the BMS and about the active user participation during the development.
- During the evaluation, users learned to trust the BMS more and more. They made less use of the paper map.
- Especially in situations without visual contact between the different vehicles, the BMS was considered to increase the Situational Awareness significantly.
- The frequency of position updates was considered too low. Users want a near real time display of the position information (updates about every 2 seconds). The bandwidth of the military radio is the main bottleneck here.

3.4.2 Evaluation 'Rhino Integration'

The evaluation 'Rhino Integration' was conducted in October 2000. This evaluation involved another command level, that is, the staff of a battalion (the 17th armored infantry battalion) and its subordinate units. The functionality to create and distribute plans and overlays was added to the BMS. The objective of this evaluation was to determine whether the plan functionality was suited for task and to see in what way the staff of a battalion would use the BMS.

The battalion staff consisted of ten vehicles, some of them armored personnel carriers and some of them shelters loaded on trucks. Each vehicle had two BMS stations inside. The battalion staff was divided into three parts, which were connected through a Wireless LAN. The three parts were positioned on the exercise area with in-between distances of 50 to 100 meters. The subordinate units (three companies, one reconnaissance platoon, one mortar platoon, one section of military engineers and one anti-aircraft artillery unit were not in the field, but inside a building. The distance to the exercise area was about 1 kilometer. Because of the tight bushes and large buildings between the subordinate units and the exercise area, a special data radio (the NTDR) was used for the communication between these locations. The people forming the subordinate units played the so-called 'lower control' (LOCON) and were also operators of a simulation program (in this case KIBOWI, a Dutch system). The simulation program caused events, upon which the LOCON units had to respond. By means of the BMS and the radio, they communicated with the battalion staff.
The configuration during the evaluation is depicted in Figure 7.

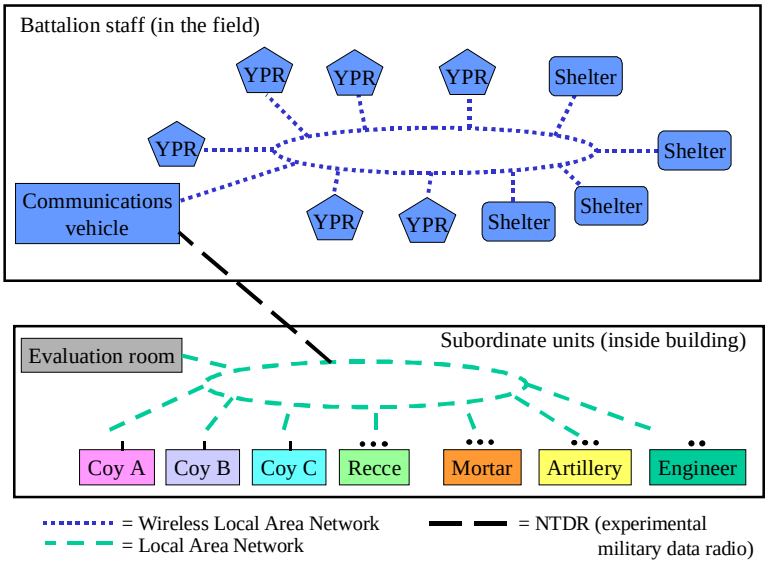

Figure 7: Rhino Integration configuration

Also the exercise controllers, in this case a small brigade staff, were in the possession of a BMS, but since they also had to act as exercise controller for two other battalions (which did not have the BMS), they did not really use the BMS during the exercise.

Prior to the exercise, the initial plan, which consists of a set of overlays, was entered into the BMS by the S3 of the battalion staff. At the start of the exercise, even before the issue of order, the battalion commander distributed this plan to his subordinate commanders. This enabled the subordinate commanders to better anticipate the issue of order and to start their own planning cycle sooner.

During the exercise, which included both a defensive and an offensive phase, the users made the following remarks:

- Situational Awareness increases as a result of using BMS.
- Running exercises with BMS increases the workload of the units, both during the preparation of the exercise and during the exercise itself. The increased workload during the exercise is amongst others a result of the fact that existing procedures are not perfectly fit to using a BMS. However, this increased workload is acceptable to users, because user involvement will lead to a better BMS (and procedures) in the future.
- When combining a BMS with other computer systems, effort must be put into the integration of both systems. In this case, a war game was used to simulate the behavior of the units. Because the BMS was not integrated with this war game, the operators often had to enter the same information twice.
- Working with BMS was ‘fun’. Many users were very interested in the development of this type of new systems. Most users presented useful suggestions for extensions to the BMS functionality.

The figures below show some impressions of the exercise Rhino Integration.

Figure 8: The command post of the battalion

Figure 9: Users working with BMS inside an armored vehicle

Figure 10: Engineer working with BMS

Figure 11: LOCON working with BMS and war game

Figure 12: Screenshot of BMS during Rhino Integration

3.4.3 Planned evaluations

For the future, there are already two evaluations planned. The first one, called "Digital Fusilier", will be held in the first week of June 2001 (at the time of publication of this paper, the evaluation will be already over). This evaluation will be very similar to the evaluation "Rhino Integration" The main difference will be that this time the 17th armored infantry battalion will have to be more independent of the BMS team. The BMS team will observe the preparation and execution of the exercise, but when there are any problems, the 17th battalion will have to solve them on their own. Only in special circumstances, support from the BMS team will be provided. This approach was chosen in order to ensure that the 17th battalion is capable of working with the set of BMS stations that will be handed over to them by mid 2001. This will enable them to do more tests during the rest of the year 2001, without having to depend on the assistance of the BMS team.

The second planned evaluation will take place in the autumn of 2001, in Bosnia. During this evaluation, the Dutch units that form SFOR 10 participate in a two-week test period where the BMS will be used during a peacekeeping operation. The goal of this evaluation is to determine whether the existing functionality is suitable for peacekeeping operations, even though it was developed with traditional article V operations in mind. The second goal of this evaluation is to test the communication between BMS stations through satellite communication.

4. Conclusions

The conclusions of making use of users while developing a BMS are:

1. By actively involving users in the development of systems like a BMS, they feel more committed to the system. They see the system more as 'their system' than just another system that was forced upon them by some developers.
2. Frequent contact between users and developers leads to a better understanding of the tasks the system has to perform, for both users and developers. This enables the users and developers to actively participate in solving problems.

3. By choosing relatively short development cycles, there is always a concrete goal everyone is working towards. This goal will be no more than a few months in time away.
4. After each evaluation, that means every four to five months, the military users know exactly what the status of the development process is. They know what has been implemented and what not. Their expectations for the next cycle emerge from the same starting point, which makes ‘expectation management’ easier. After a few cycles, users learn to estimate the amount of work that can be done within a development cycle and they more or less know what to expect in the next evaluation.
5. To people involved in more traditional system development, the ‘BMS approach’ seems slow and costly, because of a large overhead. The time available for real software development is limited compared to the total time spent each cycle. However, both BMS developers and users feel that this is a very good approach, especially in projects where nobody knows exactly what the final product will look like.